XXVIII.—*On the Development of the Germinal Streak of* Mysis. By R. S. Bergh, of Copenhagen *.

My investigations commence approximately at the stage at which the segmentation has concluded and the formation of the germinal layers begins. On the termination of the process of segmentation the blastoderm has extended round the yolk in every direction, and there now arises a thickening of the blastoderm in the form of a transverse streak (this streak occupies a transverse position with reference both to the longitudinal axis of the ovum as also to the subsequent longitudinal axis of the embryo). In this thickened streak the cells are at first arranged in only a single layer, and the thickening is consequently occasioned merely by the greater height of the cells of this region. Soon, however, the streak becomes bilaminate at a certain spot in the neighbourhood of the median line, since some few cells push their way inwards and shortly afterwards undergo active multiplication within the outer layer. I have observed stages in which only two, four, or six inner cells are present, but the number soon becomes much larger; figures of nuclear division are frequently met with. The inner mass of cells which has thus been formed now speedily separates into three different rudiments:—(1) certain cells wander about and develop into *vitellophaga* ("Vitellophagen"); (2) other cells (which adjoin the median line) become more firmly united together into a plate and constitute the true (intestinal) endoderm; (3) towards the sides certain others develop as *primitive cells of the muscle-plates* (mesoderm of authors). The final number of these primitive cells is four on each side, though in earlier stages not so many of these larger lateral cells are to be seen. As soon as the definitive number is reached these cells commence to produce smaller ones in front by the process of budding ("Knospung"); thus four longitudinal rows of cells are formed on each side within the ectoderm, so that in certain stages any transverse section from the region in question contains four muscle-plate cells on either side. With further growth the muscle-plates become very distinctly segmented, and I see no reason to doubt that their divisions correspond to actual proto-segments. The latter soon become separated from one another, since the growth of the muscle-plates does

* Translated from the 'Zoologischer Anzeiger,' xv. Jahrg., no. 406, November 28, 1892, pp. 436–440.

not keep pace with that of the ectoderm, so that the divisions of the germinal streak which contain proto-segments alternate with others in which no elements of the muscle-plates are to be found: by this means this "primitive segmentation" can be recognized with peculiar distinctness. Each proto-segment at first consists of a simple transverse row of cells: it is not until later on that these multiply, so that the rudiment gradually comes to consist of several rows and several layers, when, owing to the fact that the proto-segments then fuse together, the muscle-plates develop into a continuous layer within the ectoderm.

The ingrowth alluded to above, through which the deeper cell-layers of the embryo are formed, without doubt corresponds to the gastrula-invagination, from the lateral margins of which the formation of the muscle-plates consequently proceeds in this case also. Whether these muscle-plates belong genetically to the ectoderm or to the endoderm it was impossible to decide, and the question is one of those which in many cases are most difficult of all to determine, but nevertheless are often "decided" with the utmost arbitrariness. The blastopore has no relation whatever either to the mouth or anus; its situation is in the neighbourhood of the future anus: this, however, does not arise until much later, long after the blastopore has become completely unrecognizable. Before the formation of the gastrula-ingrowth no yolk-cells are to be found.

At the anterior margin of the blastopore a very peculiar differentiation of certain ectoderm-cells takes place: these develop into *primitive cells of the ectodermal portion of the germinal streak*. The definitive number of these cells is *seventeen* or *nineteen* (I find sometimes the one, sometimes the other); they form a transverse arcuate streak in front of the blastopore. The first stages of the differentiation and grouping of these cells seem to last only a very short time; for, in spite of the fact that I examined a very large number of germinal disks at such stages, I am only able to assert that I have found stages with nine, eleven, thirteen, and fifteen primitive cells; less than nine primitive cells were not found, and consequently no transition between this stage and the earlier phase, at which such a grouping of the cells is altogether indistinguishable; it was likewise impossible to determine whether the original nine cells multiply into the seventeen or nineteen by means of fission or whether their number is augmented by accessions from other neighbouring cells.

So soon, however, as the definitive number * is attained, these cells commence precisely the same process as the primitive cells of the muscle-plates (the cells lying nearest to the median line are the first to begin, and are followed by those occupying a more lateral position) : they produce smaller cells in front by budding ("Knospung"). In this manner there consequently arises *an ectodermal germinal streak, formed of seventeen or nineteen longitudinal rows of cells.* The cells of this germinal streak are also seen to be arranged very regularly in transverse rows, and the cell-divisions take place precisely in the same manner and with the same regularity as I recently described in the case of *Gammarus*. A median row of cells is always found, which is derived from a median primitive cell; therefore the number of the primitive cells and of the rows of cells is always an uneven one.

This ectodermal primitive streak extends in front as far as a line which connects the points of insertion of the right and left mandible. In front of this line we find in all stages under consideration a mosaic of ordinary polygonal ectoderm-cells, which are not arranged in rows and are not derived from the above-mentioned primitive cells. It seems to me that this fact, that *the ventral ectoderm is differentiated, so to speak, into a nauplial and* (sit venia verbo) *metanauplial rudiment*, is not entirely devoid of interest. The *Nauplius* appendages grow out from the anterior mosaic of cells; but the whole of the appendages which are situated behind the mandibles owe their origin to the germinal streak which is derived from the primitive cells. Behind the primitive cells there is formed at an early period an embryonic (provisional) forked caudal fin ("Schwanzflosse"), which is very distinct in the *Nauplius* stage. The epidermis withdraws by degrees from the chitinous covering of this caudal fin, and the definitive caudal fin is formed considerably further forward from the material of the germinal streak. It is probable that the only other structure which arises from the cell-material lying behind the primitive cells is the telson, though this is difficult to prove.

The position of the endoderm-plate in different stages is worthy of notice. Situated at first behind the ectodermal primitive cells, it travels by degrees on the inside of these and of the germinal streak very far forwards, until it enters the region of the mandibles. The primitive cells of the muscle-

* The numerical theorists of Prague are here furnished with interesting subjects for study. A comparison of the conditions of *Mysis* and *Gammarus* with reference to the validity of their laws would certainly have a brilliant result.

plates, too, lie at first close behind, but in later stages close in front of the ectodermal primitive cells. At last all the primitive cells split up into smaller cells.

When the organs (nervous system and appendages) begin to develop from the germinal streak the regular arrangement of the cells in rows gradually disappears, since they commence to divide in different planes. I am entirely unable to state positively how many of the original longitudinal rows enter into the formation of the ventral nerve-chain; it seems to me most probable that it is only the median row and the one lying next to it on each side which take part therein. Another process, however, is very distinctly recognizable in the formation of the ventral chain; for the ectoderm-cells which are destined for the production of the ganglion-cells become developed as primitive cells, which, by means of budding, give rise to rows of smaller cells towards the interior in a manner precisely similar to that which Wheeler * has described in the case of Insects. Yet in *Mysis* the "neuroblasts" (as Wheeler terms them) are not covered by the epidermis, but actually represent the most superficial layer of cells of the region in question, and, so far as I am able to observe, persist throughout as epidermis-cells, while in the case described by Wheeler they are situated within the epidermis.

A torsion of the germinal streak, such as I recently described as occurring in *Gammarus* †, does not take place in *Mysis*.

As is evident from what has been stated above, besides many points showing great agreement with the conditions which are found in *Gammarus*, several noticeable deviations from what is seen in the last-named form also occur. In this connexion the existence of the larger primitive cells at the posterior end of the germinal streak of *Mysis* is especially worthy of mention, since these are wanting in *Gammarus*. On the whole *Mysis* is a more convenient and more easily manipulated object for the study of the processes which are here alluded to. The above results were derived partly from the study of series of sections, but chiefly from the examination of transparent surface-preparations. J. Nusbaum ‡, the most recent monographer of the development of *Mysis*, has

* Wheeler, "Neuroblasts in the Arthropod Embryo," Journal of Morphology, vol. iv., 1891, p. 337 *et seq.*

† Zool. Anzeiger, 1892, no. 396.

‡ J. Nusbaum, "L'embryologie de *Mysis chamæleo* (Thompson)," Arch. de Zool. exp. et gén., sér. 2, t. v., 1887, p. 123 *et seq.*

entirely neglected the study of surface-preparations of this kind, and consequently the conditions which are here described were almost completely ignored by him. In the present brief communication I am unable to make further reference to the literature of the subject.

BIBLIOGRAPHICAL NOTICES.

A Catalogue of British Jurassic Gasteropoda. By W. H. Hudleston, M.A., F.R.S., P.G.S., and Edward Wilson, F.G.S. 8vo. Pp. xxxiii and 147. Dulau and Co.: London, 1892 (November).

The very aspect of the pages of this book reminds a working Geologist of the well-known 'Morris's Catalogue of British Fossils,' even without the allusion in the Preface to the latter still useful book, though it has long been out of print. This new Catalogue, however, is limited (as its Title intimates) to one Molluscan group of one Formation, and has very good additional features in its lists of localities, bibliographic catalogues, table of genera, notes on some genera and on doubtful and rejected species. Moreover, the synonymy and references are far more liberally represented than in the former work.

The plan of this Catalogue is clearly laid down in the "Explanatory Note," pp. xi–xvi; and the palæontological bearings both of the whole group and of its divisions are treated of in the Preface, pp. v–x.

The long experience and the accurate knowledge of the two energetic Authors may be well trusted for the satisfactory fulfilment of the task they have undertaken and brought to publication in this work; and their nomenclatorial and general literary style and method are decidedly good. Great pains have evidently been taken to have quite correct printing; and severe judgment has evidently been exercised in coming to a conclusion in cases of doubtful priority, in choosing the best and most necessary references, and in determining the synonymy.

Sixty-five genera and subgenera of British Jurassic Gasteropoda, with their frequently numerous species (122 in *Cerithium* and 78 in *Pleurotomaria*, for instance), constitute the chief material here reduced to zoological order, as far as the often imperfect preservation of the shells permits. The six genera from the Rhætic Beds are similarly treated (pp. 137–139).

Thus all the evidences that the relics of Gasteropods in the British and, in many associated instances, foreign Jurassic strata can yield to the experience of experts, as to zoological and geological conditions and changements, are here brought to our convenient